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THE POPULATION OF THE "BLANKET-ALGÆ" OF FRESHWATER POOLS[1]

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THIS is a study of the community of life that is bound up with the floating masses of filamentous algæ, popularly known as "blanket-algæ." An acquaintance with this population is worth cultivating for the sake of the variety, beauty and interesting peculiarities of the plants and animals found in this unique habitat. It may be of utilitarian value as well, for there exists a relation between plankton production, algal growth and fish culture. Furthermore, it may be a help to students and to teachers of biology when they are in search of certain laboratory materials, which in these algæ masses flourish.

Method of Collecting.—A fine silk hand net of No. 12 bolting cloth was used to lift the algæ from the surface of the water. The largest collection covered about 2,800 sq. cm.; the smallest about 10 sq. cm., but most of them were from 200 sq. cm. to 800 sq. cm. in area. Doubtless, many active and comparatively large foraging animals, such as small fishes or adult insects, escaped while the net was surrounding and enveloping the mass. Probably comparatively few of the smaller forms were lost through the fine silk mesh of the net. The volume of the mass was then computed in cubic centimeters. As the mass sometimes lay in thin layers and sometimes in thicker masses, the proportion of volume to surface was seldom the same. About 200 cu. cm. was the average. The components of the "blanket" were determined and all forms, plant and animal, were listed and their size and relative abundance noted. The collections were made during the fall and early winter of 1912 and the spring and early summer of 1913.

Location and Character of the Pools.—The pools are all located in the vicinity of Cornell University campus at

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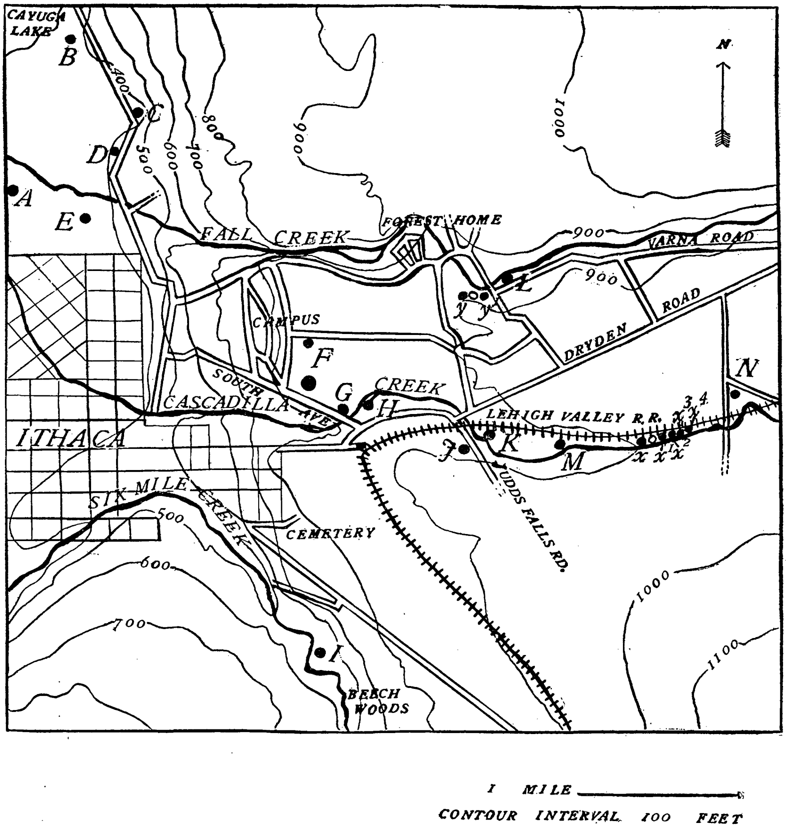
[1] This study was carried on in the limnological laboratory of the department of entomology of Cornell University under the direction of Professor James G. Needham.

Ithaca, N. Y. (see map). They varied from shallow, transient collections of ditch-water to large, permanent, usually stagnant pools. Those lettered *B, C, D, G, J, M,* and *N* belong to the first category. Pools x, x^1, x^2, x^3, x^4, and y, y^1, *E, K, I,* and *L* are permanent pools and measure from four to thirty or more inches in depth. Pool *H* is a quiet part of a large stream. Pools *F* and *A* are artificially enclosed and are filled from pipes. The pools of the lowland of Cayuga Valley (about 400 ft. above sea-level) are *A, B, C, D,* and *E*. The others are among the hills (about 800 feet above sea-level).



Pools in the Vicinity of Cornell University Campus.

The Filamentous Algæ of the Floating Mass.—Although there was such variety in seasonal conditions and in the location and character of the pools, nevertheless some forms appeared constantly. Among the filamentous algæ, *Spirogyra* was almost uniformly present, appearing twenty-eight times out of thirty. The species were not identified until March, but in the twenty collections taken in the spring and early summer, the most frequent species was *Spirogyra varians*. *Spirogyra insignis* was found five times. Other species seen less frequently were:

S. tenuissima
S. sticticum
S. grevilliana
S. weberi
S. quinina
S. crassa
S. majuscula
S. communis
S. fluviatilis
S. bellis
S. nitida
S. inflata
S. decimina
S. rivularis

Usually the masses contained several species of *Spirogyra*, often with a large proportion of one species, and the *Spirogyra* was almost invariably associated with other filamentous algæ. Among the most frequent of these were *Mougeotia* and *Zygnema*. *Vaucheria* was found frequently in the autumn and early winter. *Oscillatoria* was quite constant after its first occurrence in early March, but it was usually in very small quantities. *Ulothrix Draparnaldia* and *Microspora* were seen occasionally, but not in abundance, while *Anabœna oscillaroides* was found only once. In general, the large permanent pools produced the greatest variety of genera and species of these algæ, but otherwise there was no apparent relation between the genera of algæ produced and the character and location of the pools; with the possible exception of *Draparnaldia plumosa,* which was found four times out of five in shallow ditches.

Diatoms, Desmids and Other Algæ.—Diatoms were invariably present. Of these, there were four that were constant and always in greater quantity than other kinds. These four were *Navicula,* in great variety, *Synedra, Cocconema* and *Gomphonema.* Other diatoms were seen irregularly as to quantity and time of occurrence and included the following:

Tabellaria
Fragillaria
Meridion
Asterionella
Diatoma
Encyonema
Cymbella
Cocconeis
Campylodiscus
Amphora
Pleurosigma
Nitzschia
Odontidium
Cyclotella

Most of these were free but often *Gomphonema, Cocconema* and *Cymbella* were in colonies attached by branched or simple stalks to larger forms. *Encyonema* is found end to end in colonies enclosed in long filament-like gelatinous envelopes. *Navicula* as well as stalked diatoms sometimes covered the bodies of larvæ and smaller crustaceans and also the cases in which the chironomid larvæ spent part of their time. Variation in occurrence of diatoms is apparently due to seasonal changes, which will be considered later.

Other algæ were less constant, the most regular one being *Closterium,* which occurred in eight collections, showing a number of species. Of the other desmids that appeared, *Cosmarium, Penium* and *Staurastrum* were usually in small quantities. Twice, however, *Cosmarium* and *Closterium* both appeared in abundance, the first time being in a permanent but shallow pool (*I*) where *Ulothrix* predominated, and the second time in a shallow but probably permanent roadside pool (*G*) covered with *Spirogyra.* The Volvocaceæ were represented by *Volvox, Eudorina, Pandorina, Sphærella* and *Chlamydomonas.* Two Phæophyceæ, *Dinobryon* and *Synura,* and four Protococcaceæ, *Dictyosphærium, Kirchneriella, Protococcus* and *Scenedesmus,* added variety but did not appear frequently. *Peridinium, Pediastrum* and *Ophiocytium* were rare.

The pools (*L* and *Y*) that had the greatest variety in desmids and kindred forms were also rich in diatoms.

These pools are large and one or two feet deep and have thin mud overlying rock bottom. Both lie near Fall Creek.

The pools (K, x, x^1, x^3, x^4) near Cascadilla Creek presented the only specimens of *Dinobryon* that were seen. These pools are permanent and deep and have stony bottom.

It may be significant that in the low-ground pools there were few kinds of diatoms and in only one such pool (A) were there any desmids.

The Animal Population.—The floating and entangled vegetation of these masses supports a large animal population. The protozoans found were particularly varied and interesting. *Ameba*, *Arcella* and *Difflugia* appeared irregularly in the upland pools. *Cochliopodium* and *Mastigameba* were rare. No other Rhizopods were observed. The ciliates were not determined before March, with the exception of *Paramecium*, which was listed from the first. In the twenty collections made since March first, fifteen genera of ciliates have been observed. *Paramecium* was constant and abundant. Among the larger representatives of the group, *Coleps, Chilodon, Colpidium, Stylonychia* and *Vorticella* appeared frequently and in large numbers. *Stentor, Dipleurostyla* and *Amphileptus* were less frequent, as were the smaller members of the group, namely, *Euplotes, Halteria* and *Askanasia*. *Coleps* was especially noticeable in pool y^1, while *Vorticella* was plentiful in pools D and G. Pools D, G and J, which supplied the largest number of genera and of individual ciliates, are shallow ditch-pools with muddy bottom, while A and Y in which smaller numbers were found, but still many genera, are larger and deeper, but have muddy bottom or muddy water. From this it seems evident that these protozoa prefer water with inorganic material in suspension, although they are said to avoid water polluted by decaying organic matter. These tiny creatures forage busily among the algal filaments, some swimming and rotating smoothly, others, such as *Halteria* and *Stylonychia*, moving by jerks and sudden dartings hither and yon. The minute form, *Euplotes,* has a peculiar method of locomotion that looks like walking along a filament, though it is merely forward progress by means of cilia.

The flagellates were represented by *Euglena, Distigma* and *Phacus,* of which the first was fairly constant. Three heliozoans, *Actinosphærium, Actinophrys* and *Vampyrella,* appeared infrequently. *Hydra* was found in one collection only, and no other cœlenterates were seen.

Various worms, mainly the microscopic nematodes as well as unidentified planarians and turbellarians, also three kinds of oligochætes, namely *Nais, Tubifex* and *Chætogaster,* were frequent but not regular inhabitants of the alga-mass.

The rotifers were regularly a part of the population, furnishing species of eighteen genera. Determination of genera was not undertaken until March The genus most constantly in evidence was *Diglena,* especially in dirty water, foraging industriously, nibbling and pulling at the algæ. A species of Metapidia with a broadly curved lorica was seen several times. It clung by its toes to debris, while the flow of water carried food-particles past the rotating cilia into the mastax. *Anurea, Salpina* and *Synchæta* were found exclusively in the pool nearest Cayuga Lake, pool *A*. Also in this pool, as well as elsewhere, were found *Polyarthra, Rotifer, Adineta, Diglena, Notholca labis* and a long-spined species of *Rattulus.* This permanent pool and a similar pool (X^1) of the highland were richest in rotifer life. Forms found in the latter pool and not observed elsewhere, were *Notommata* and a species of *Stephanops* with a fan-like anterior projection of the lorica. Other genera identified were *Brachionus, Philodina, Mytillina, Mastigocerca* and *Diaschiza. Chætonotus,* a representative of the *Gastrotricha,* was seen a few times.

The Gastropoda, the only mollusk group represented, did not furnish a constant element, since only eight collections contained any snails. *Lymnea* appeared once, *Physa* five times and *Planorbis* four times. These snails varied in size from two to twenty-five mm. long. Except in one instance, they were in shaded pools or came out on cloudy days. The exceptional case may be considered as similar because the luxuriant growth of watercress near the algae furnished spots of shade, although most of the "blanket" was in sunlight. It seems fair to assume that snails are not regular inhabitants of the surface algæ, but merely forage there when there is little or no sunlight.

Many small crustaceans were observed. *Chydorus* and *Bosmina* were numerous, while two other Cladocera, *Daphnia* and *Simocephalus,* were less in evidence The ostracods found were in eleven collections and quite numerous. They have not been identified. *Cyclops, Canthocamptus* and *Diaptomus* were the copepods identified. *Cyclops* was remarkably constant and abundant. Many females bearing paired egg-sacs and many copepod nauplii, presumably young cyclops, were among the number. The adults were from one to three mm. long. The Isopod, *Asellus aquaticus,* was found only once and then in a mass of algæ close to a mud bank. Two amphipods, *Gammarus* and *Hyalella,* were observed several times.

The last group of foraging animals and the one to which the largest individuals of this population belong is the Insecta. In this class were found larvæ, nymphs and adults, representing five orders of insects. Three nymphs of *Callibœtis,* in pool *A,* one of *Bœtis,* in pool *M,* and ten of undetermined genera of *Ephemerida* in Pool *F* were the only may-fly nymphs found. The *Odonata* were more frequent. There were a few Libellulids, and a number of nymphs of *Enallagma* and *Ischnura.* The Hemiptera had only one representative, *Corisa,* the water-boatman, which was caught twice but was frequently seen swimming on the clean surface of the pool. It can hardly be considered a regular inhabitant of the alga-masses.

Four different larvæ of the order Diptera made up the greater part of the insect population. *Chironomus* was particularly conspicuous, since the larvæ were found constantly, and were generally very numerous. Masses of eggs of *Chironomus cayugæ* Johannsen were found enclosed in an oval mass of gelatin anchored to some of the algæ, also myriads of newly-hatched, almost microscopic larvæ were seen, so it is reasonable to assume that, for these pale pink or yellowish chironomus larvæ (1–18 mm. long), this environment is the normal one. A few larger species, some of them blood-red, were found also. Larvæ of the "punkie" *Ceratopogon* and of the soldier-fly, *Odontomyia,* were seen occasionally. Although mosquito-larvæ are found regularly in stagnant pools, it is surprising to note that only twice were these larvæ found among the filaments of the floating algæ. These larvæ were not identified.

A few larval beetles and a few adults made infrequent appearances. Undetermined *Hydroporus* and other dytiscid larvæ were among these. Although known as a dweller among filamentous algæ, the Haliplid beetle larva, *Peltodytes,* was seen only once, its long spiny hairs tangled in the vegetation. Adults of two genera of Hydrophilid beetles were identified as *Helophorus* and *Crenophilus* and a few other diving-beetles were seen but not identified.

Although tadpoles, and once a young salamander, were found in the collections, they can hardly be reckoned as members of the society under consideration.

Dominant Forms.—In this diverse population the constant and abundant forms have been few. *Spirogyra,* especially *Spirogyra varians, Mougeotia* and *Zygnema,* were the principal constituents of the "blankets." Among the Diatoms, the dominating forms were *Cocconema, Navicula, Gomphonema* and *Synedra.* Other algæ were best represented by *Closterium, Dictyosphærium* and *Dinobryon.* Among the animals *Paramecium, Euglena* and the rotifer, *Diglena,* were quite constant. The forms that appeared most regularly were *Cyclops* and the larvæ of *Chironomus.* Some of the less constant forms showed the influence of seasonal variation.

Seasonal Variation.—In the autumn and early winter *Vaucheria* was usually present, but appeared only twice in the spring. *Pandorina* and *Peridinium* also appeared late in the year. At that time fewer protozoa were seen than in the spring, but, as has been said, variations here seem to be more closely related to the character of the water than to the temperature. *Gammarus* and the nymphs of may-flies and dragon-flies were most numerous in October, November and December.

The spring season also had its special forms. *Oscillatoria* appeared first in March and was constant thereafter. Diatom production was at its height in April and May at water-temperatures varying between 8° and 16° C. and there was a marked decline in diatom appearances toward the end of June. In contrast to diatoms, desmids seem to require higher temperatures, since most of the *Closterium* and all of the *Cosmarium* and *Staurastrum* that were seen appeared in June, in water at temperatures between 15° and 20° C. The proportion of *Dinobryon* in collections became noticeably greater during the latter part of June. The smaller crustaceans, excepting the ever-present *Cyclops*, showed marked increase in numbers as well as in diversity during May and June. The same seasonal increase was noticed for *Anguillula* and the rotifers. Most of the coleopterous and dipterous larvæ were found in May and June, except *Chironomus* which was present at all seasons.

Another point of interest in connection with seasons is the time of reproduction. *Spirogyra* was found conjugating in October, April and June; *Mougeotia* in November, December, May and June. Young, sessile plants of *Ulothrix* were seen in April and May. All through the year, copepod nauplii and female *Cyclops* bearing egg-sacs were observed. *Chironomus* eggs were found in April and early in June, while very young larvæ were abundant during April, May and June.

In view of the fact that floating algæ were found in large quantities in December, even under ice, it was surprising to find some of the pools totally devoid of this kind of vegetation in spring. Pools *K, M,* x, x^1, x^2, x^3, x^4 showed this peculiarity. Their "blanket-algæ" did not reappear until May. This disappearance of surface vegetation may have been due to spring freshets, as the pools mentioned are in the flood-plain of Cascadilla Creek, although not in the stream-bed.

The Natural Balance.—Like other societies, the population of the "blanket-algæ" has its producers and its consumers, its hunters and its hunted, each readily exchanging rôles as occasion demands. The synthetic organisms include with the phytoplankton a few chlorophyl-bearing organisms of the zooplankton; that is, forms like *Euglena, Phacus* and *Distigma,* which, in sunlight, have the holophytic method of feeding (Stokes, 1895). Diatoms require nitrates, silica and some salts to make their dainty and beautifully marked shells. Since they are comparatively heavy, they sink slowly, but are brought to the surface during the spring and fall circulation of the water. In spring they multiply rapidly near the surface, since they need oxygen and sunlight.

Many of the tiny creatures, including ciliates, *Cladocera,* rotifers and nymphs and larvæ of some insects are in search of diatoms. These animals eat other tiny food particles as well as diatoms. The rhizopods, *Arcella* and *Ameba,* ingest diatoms, desmids, small protozoans and even rotifers. *Vampyrella* consumes the cell-contents of algæ. *Actinophrys* prefers the spores of algæ, but takes small protozoa. *Actinosphærium* is omnivorous (Stokes, 1895). Many of the ciliates eat diatoms and other ciliates. The food is drawn into the oral opening by means of currents of water which are directed toward the opening by the constant motion of cilia. One ciliate, *Chilodon,* has a peculiar method of feeding. It protrudes a broad flexible lip-like expansion of the anterior end and gathers up food particles with a sweep of this organ.

Turbellarian worms feed on rhizopods, ciliates and rotifers. Rotifers eat diatoms and some nibble algæ, whereas the closely related Gastrotricha, *Chætonotus,* eats minute particles of decayed animal and vegetable matter, rarely taking diatoms.

The smaller crustaceans in general and the snails are scavengers, removing decaying algæ and bits of dead insects or other animal matter. The Cladocera, however, are said to eat diatoms and many of the smaller algæ. Ostracoda are omnivorous and often attack their own species.

Among the insect members of this society, the larvæ of the may-flies and midges are the great herbivores, although, in addition to algæ, diatoms and leaves of higher plants, consuming a great variety of vegetable substances, both living and dead. The great abundance of *Chironomus* larvæ make this genus an important factor, both as a consumer, and as food for other animals. *Chironomus* larvæ and pupæ are, in turn, eaten by dragon-fly nymphs, and other predaceous larvæ. They are of much importance as fish-food.

Dragon-fly nymphs are predatory. Some species eat back-swimmers and water-boatmen, small crustaceans and snails, coleopterous and dipterous larvæ and even young dragon-fly nymphs. The larger nymphs are eaten principally by fish, occasionally by water-birds.

This brief account of some of the feeding-habits will serve to show how much all the members of this society are dependent upon the others, and, at the same time, are in constant danger of extinction. Each form acts as a check upon too rapid multiplication of some other form. Since the most prolific animals in this population are *Cyclops* and *Chironomus,* each must have peculiarities that enable it to survive in this environment and to compete with other animals. *Cyclops* adapts itself easily to changes. Its prolific reproduction, seasonal constancy, and plasticity, give it great advantage over other small crustacea. *Chironomus,* also constant, prolific and adaptable, finds abundant food and comparative shelter among the algal filaments.